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THE CANADIAN ECLIPSE EXPEDITION

THE MEASUREMENT OF THE EINSTEIN PLATES

By R. K. YOUNG

THE organization of the Canadian Expedition to Australia and an account of the apparatus and the success of the expedition has already been given in this JOURNAL by C. A. Chant. Upon the return of the Expedition to Canada in November Dr. Chant entrusted the measurement and reduction of the Einstein plates to the writer. The University of Toronto possessed no suitable measuring engine. The purpose of the following article is to explain as simply as possible the methods of measurement and reduction of the plates taken in Australia and to present the main results. A more detailed presentation will be given later.*

According to the theory of Einstein the rays of light from any source, such as a star, when passing the sun are subjected to a gravitational pull and are bent inwards, the amount of the bending being greater for rays close to the sun than for those farther out. In consequence of this deflection of the light rays the stars in the neighbourhood of the sun should appear displaced outward from their normal positions. The displacement varies inversely as the distance from the sun. For stars at the limb of the sun the deflection amounts to 1.75 seconds of arc, for stars about 16 minutes

*A full statemect of the measurements and the reduction of the plates will will be printed in a *Dominion Astrophysical Observatory Publication*—C. A. Chant.

away from the sun it is only half this value, for stars 32 minutes away one third, and so on. Stars in the neighbourhood of the sun can be photographed during a total eclipse of the sun, at which time the disc of the moon covers up the bright surface of the sun and the sky around the sun is comparatively dark. Two exposures were made at the eclipse and on each of these negatives appear the moon's disc, the corona and about twenty-five star images. However, some of these images are very faint and only 19 were subjected to measurement and three more were rejected later.

In order to test the positions of the stars on the plate for shift it is necessary to have, in addition, photographs of the same region, taken with the same camera when the sun is not in that part of the sky. These should be taken under as nearly as possible the same conditions, the same position of the telescope and at the same station. It was impossible to secure these in the present case as the north-west coast of Australia is a very inaccessible shore, with no facilities for living, and it would have been necessary to proceed there several months in advance. The idea that check plates of the eclipse region could be secured almost as well, if not equally as well, on the Island of Tahiti occurred to W. W. Campbell, the leader of the American Expedition. The reason that plates taken at Tahiti serve is, that Tahiti has almost the same latitude as the Eclipse Camp at Wallal, and if the plates are taken at the proper time, or hour angle, the displacement of the positions of the star images due to refraction are almost identical in the two cases.

Dr. Trumpler, of the American Expedition, proceeded to Tahiti several months in advance of the eclipse with the cameras of their expedition and secured these very essential photographs. As explained by Dr. Chant in his account of the expedition, Dr. Trumpler took exposures of the same region with the Canadian party's camera, which was shipped to Tahiti for the purpose and designed so that an attachment would adapt it for the Lick Observatory mounting. In addition Dr. Trumpler secured for us a plate of the eclipse region taken through the glass, *i.e.*, with the glass side exposed toward the lens. The purpose of this plate will be explained later.

We have then five plates to proceed with in the measures, two plates taken at the Eclipse Camp with the corona and surrounding stars, two plates of the same region when the sun is absent and one plate of the same region taken through the glass. We designate these E_1, E_2, C_1, C_2, and I, respectively.

To the novice it might appear very simple to test the positions of the images on these plates. He might suggest the superposition of plate E_1 on C_1 and by direct inspection imagine he could detect the shift. There are many factors which prevent such a direct test. In the first place E_1 and C_1 being both negatives can only be superimposed film to glass and in this position, with the thickness of the glass between the two films, the relative position of the star images depends on the position of the observer's eye. The plate I was taken to overcome this difficulty. When this plate is placed film to film with any of the other four plates, the star images appear in pairs. It would not do to assume that the images on I are in their normal positions, for the light in passing through the glass may have been, and undoubtedly was, in some cases bent from its normal course. The resulting position of the image would be in error. Even if this were not the case the procedure would not do because the displacement due to the Einstein shift is only a very small fraction of the diameter of the images and the images might appear superimposed when in reality a small shift was present.

The correct procedure is to clamp the two plates firmly together by means of suitable clamps, the plates being so placed that the pairs of images are reasonably close together all over the plate, and then to measure the relative positions of the pairs of images, and from a discussion of these measures to ascertain the correct positions and the displacements governing them.

On the measuring engine at the Dominion Astrophysical Observatory, which was made by Repsold, the relative positions of the two images are measured in rectangular co-ordinates, Δx and Δy being obtained for each pair of stars. The plates were first securely clamped together and then measured in both the direct and reverse positions by myself and afterwards by Mr. Harper, to whom we are much indebted for this valuable assistance. From 5 to 8 readings were taken on each image and in both the

direct and reverse measures and by each observer. The mean of our values was adopted as the measured Δx and Δy. This work was carried through for the combinations E_1 to I, E_2 to I, C_1 to I and C_2 to I. It will be obvious even to those unacquainted with such work that the relative positions of the images on E_1 to C_1 are given by the differences $E_1I - C_1I$ and of those on E_2 to C_2 by $E_2I - C_2I$, so that in the discussion which follows we will imagine this difference always taken as if E_1 had been compared directly with C_1 and E_2 with C_2. When we examine the Δx and Δy for the various stars we find that they are not equal all over the plate. Let us enquire why is this so. The first reason that occurs to us is that the position of each star image on the photographic plate is affected by atmospheric refraction. The effect of refraction is to make the position of each star appear nearer the zenith of the observer than it really is. The amount of the shift is greater for stars nearer the horizon than for those higher up. The stars on the lower half of the plate will be shifted more than those on the upper half and while the effect is present on both the Eclipse plates and the Tahiti plates and in general to nearly the same extent, there is a small secondary difference because the latitude of Wallal and Tahiti are not exactly the same and because the plates were not taken at exactly the same zenith distance.

The correction for refraction is one that is capable of computation and can be allowed for. There is also an effect due to aberration of light which can also be computed and we will imagine that this computation has been performed and each Δx and Δy for each star image corrected. We will still find that they differ for the various star images. These differences depend on the manner of superimposing the plates and on the shifts of the star images due either to change of scale or to the Einstein shift and the problem is to sort out the causes of the observed values of Δx and Δy.

We will make the nature of the problem clear by means of diagrams. Suppose we have two star plates, the first with the sun in the centre and star images situated farther out. Let the star images lie in circles one circle close in to the sun, one a little farther out and one still more remote. On the actual eclipse plates the nineteen images are situated irregularly over the plate

but it will help understanding the method if on these imaginary plates we suppose the star images situated in standard positions. Suppose the second plate an exact duplicate of this with the sun image left out. If these plates are superimposed and the centres shifted a little to one side we would obtain pairs of images as in Figure 1.

Fig. 1

In this case the Δx and Δy would be the same for each pair of stars. Let the shift be c in the x co-ordinate and f in the y co-ordinate.

In addition to the two plates being shifted it will always happen that one is twisted a little with reference to the other. The nature of the shift that would occur in the relative positions of the images due to this cause is illustrated in Figure 2.

The outer images are shifted the farthest, the inmost ones the least. The amount of the shift is proportional to the distance of the star from the centre of the plate. If we let b be the displacement of the image due to this cause at unit distance then the displacement at a distance r is br and it may readily be shown that the dis-

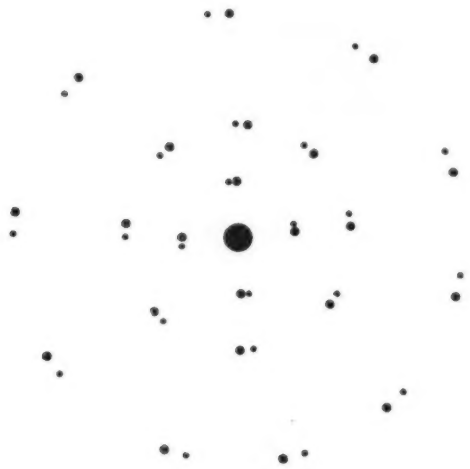

Fig. 2

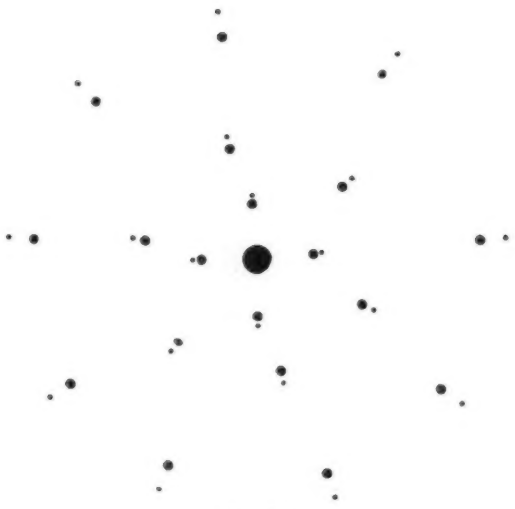

Fig. 3

placement in the x direction is by and in the y direction $-bx$. Since we are measuring the two co-ordinates independently, however, let b be the constant for the x direction and d be that for y direction. When these are finally determined b should equal $-d$. The two preceeding causes for displacement depend upon the superposition of the two plates. In addition it is quite possible, and indeed almost certain, that the two plates are not quite of the same scale, that is, one plate will be a little more enlarged or reduced than the other. It must be remembered that one plate was taken in the night and the other in the day time. Temperatures, barometer and focus would be different in the two cases. The manner in which this factor would displace the images is illustrated in Figure 3.

Again it is the outer star images which are affected the most. The displacement is again proportional to the distance from the centre of the plate but if we compute how much it is in the x and the y co-ordinate we would find that the displacement in the x direction is ax and in the y direction ay, where a represents the displacement of a star due to this cause at unit distance. As before we will introduce two constants, a in the x co-ordinate and e in the y co-ordinate. In the final solution a should be equal to e.

If the Einstein theory is true there should be in addition a displacement of the star images outward from the sun which operates in the same sense as a scale correction. The amount, however, at various distances is not the same as that due to scale. Whereas the scale correction affects the outer stars the most and the stars nearest the sun the least, the Einstein effect is just the reverse, affecting the latter the most and those farthest out the least. If α is the displacement due to the Einstein effect at unit distance from the sun, then the displacement in the x direction of any star whose co-ordinates are x and y is a function of x and y times α, or αEx, and in the y direction αEy, where Ey is another function of x and y.

The observed differences Δx and Δy are a combination of these various factors which combine linearly, that is to say, each measure for a star leads to two equations of the form

$$ax+by+c+\alpha Ex=\Delta x$$
$$dx+cy+f+\alpha Ey=\Delta y$$

In these equations a, b, c, a, d, e, f are unknowns, x, y, Ex, Ey can be either measured or computed and Δx and Δy are the results of measurement. If we measure 19 star images we obtain thus 38 equations to determine 7 unknowns. In such cases there is a mathematical process known as the solution by the method of least-squares which enables one to find the most probable values of the unknowns.

The first solution made included eighteen star images, one having been rejected as of too little weight. In the course of the measures some were marked as of greater weight than others, but in the solution all were given the same weight. The result of this solution gave for the constant when referred to the sun's limb, from E_1, 1″.38; and from E_2, 2″.09, though the results from the x and y co-ordinates were not very accordant. All the results were positive.

When the displacements from the individual stars were computed it was seen that two stars were very much in error, over 1″ of arc, and star No. 7, which had the largest expected displacement, was also considerably out. If a solution is made leaving out star No. 7 on our list, which is B.D. 1.2628, the solution from the y co-ordinate has very little if any weight. This solution was carried through. The mean result from the x co-ordinate is 1″.73, being 1.30 for plate E_1 and 2″.17 for plate E_2. The result from the y co-ordinate has very little weight but both plates give a positive result with a constant fixed at 0″.66.

A third solution was carried through including star No. 7 but omitting the two most discordant stars which were apparently having an undue influence on the result. For this solution E_1 gave 1″.73 and E_2 2″.75.

The displacements of the individual stars outward from the sun from this solution are plotted in the graph together with a curve showing the expected displacement predicted by Einstein on a basis of the constant being 1″.75.

It may be remarked that we have followed pretty closely the method of solution adopted by the English astronomers for the eclipse of 1919 as given in the *Smithsonian Report* for 1919, pages 133-176. This method presupposes the existence of the Einstein term. The reader will be able to see from the diagrams that the

constants a, b, c, d, f, are determined principally from the outer ring of stars. An alternative method of solution would have been to have used these to determine the plate constants and then computed the most probable value of the Einstein constant from the residuals left by the inner stars. This procedure theoretically

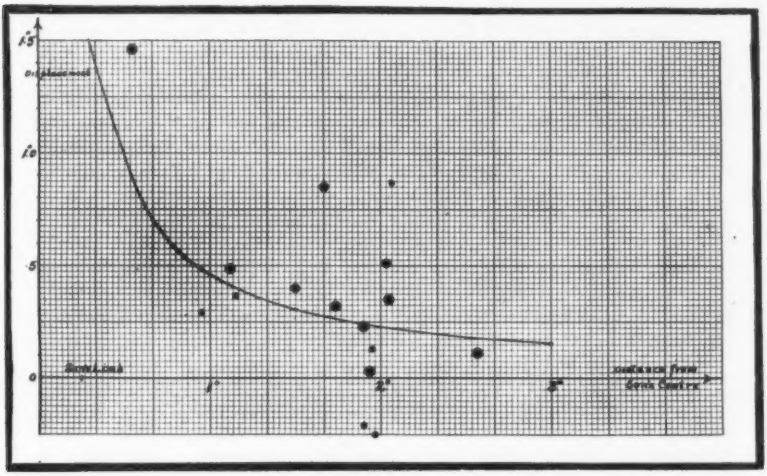

Fig. 4

has something in its favour but when the number of the stars is fairly large the two methods must yield almost identical results. In the diagram (Fig. 4) the larger circles have the greater weight.

Dominion Astrophysical Observatory,
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JÓN BJARNASON OF THORORMSTONGUE

(The original of the following article appeared in the Icelandic magazine "Thjotholfi" on January 9, 1861. It was written by the Icelandic astronomer Björn Gunnlaugsson.) (Translated by C. V. Pilcher.)

I have just learnt of the death of a friend of mine, who passed away in the north of Iceland on the twentieth of November last. He was a man worthy of the attention of his fellow-countrymen. If an English traveller like Metkalfe could feel that he had discovered a man of such singular ability that he would have believed it impossible that so brilliant a mind could ever have existed in such an environment, it is scarcely creditable to us Icelanders if we do not put on record in permanent form our knowledge that we possessed such a fellow citizen,—an uneducated farmer who in the realm of science, particularly in astronomy, had achieved greater mastery than that usual among university men, not only in Iceland but also in other countries.

I speak of Jón Bjarnason of Thorormstongue in Waterdale, a man singularly endowed by the muse, Urania. I feel it particularly to be my privilege to write of my friend, as I knew a side of him which others would find it difficult to paint. My hope is that his relatives or friends or parish clergyman will write to one of our papers describing that other side of his life with which I am less familiar.

I seem to remember him telling me, when I was in the neighbourhood of his home, that his father had refused him an education on the ground that it would not be fair to spend so much money on him—money which would have to be taken from his sisters' share. I have also heard it produced as a reason that his father had originally doubted whether he was possessed of all his wits. I feel strongly that when boys have reached the High School age, their fathers have no excuse for failing to ascertain whether or not, as a matter of hard fact, they are capable of receiving an education. I have a particular sympathy in this matter with Jón because, long after my childhood, I heard from most diverse sources that

there were men who believed that I was "not all there". I suppose the reason is that the sciences, especially Astronomy and Geometry, have lured us with their beauty somewhat away from the beaten track.

How was it that the late Jón managed to learn so much, if he had never been to school? Zoology and Mineralogy he acquired from Danish books. The same was the case with Astronomy. He procured the work of Bugge, Ursin's Astronomy and Mathematics, Bode's Star Chart, the Berlin Astronomical Tables, Mundt's Astronomy, and the Logarithms of Ursin and Lalande. I might also mention that we corresponded, by each mail, before I left the country, while I was abroad, and after my return home—now for about 39 years. I have been told that he preserved all my letters.

As a result of all this study he made such substantial progress, that he prepared an almanack or astronomical calendar in which he predicted the movements of the heavenly bodies. He was so successful in his calculations as to solar and lunar eclipses, that he determined at what point and at what time the shadow would strike the earth in the west, how it moved each minute eastwards across our globe (as a result of the motions of the earth on its axis and the moon in its orbit), how the penumbra girdled the continents, until it finally left the terrestrial ball in the east. Jón, in imagination, took his stand in the moon while he was calculating this out. When he saw that the dark part of the moon's shadow would strike the earth in the west, say at Philadelphia, he at once transferred himself to the earth and gazed from Philadelphia towards the sun. He observed the sun rising there either in annular eclipse (when a brilliant ring of solar light appears around the dark body of the moon) or in total eclipse (when nothing of the sun's light is seen except the corona). When he had observed, from his lunar standpoint, that the dark shadow was about to leave the earth in the east, say in Pekin, he at once transferred himself to China and calculated whether the sun was setting there totally eclipsed or not, as the case might be.

Nor did he leave Comets alone. He pursued them with his calculations. Metkalfe saw his calculations of eclipses and procured from him a calendar with the idea of submitting it to the judgment of Oxford University, because he believed it impossible

that Jón should be able to work out such problems. But it happened more than once that the miscalculations or misprints were found in the foreign calendars. Jón was certain to notice this and to write to me on the point. On one occasion Jón's victory was witnessed by two of us. He had written to me about a wrong date which had been assigned to a new moon. I could of course have calculated the time of new moon from the astronomical tables, but I chose a simpler way. I went to Candidate Haldor Gudmundsson, who had a copy of the *Nautical Almanac* for the current year. We then both of us saw, Haldor Gudmundsson and I, that the astronomer of Thorormstongue was right.

Jón was also interested in surveying, and began by surveying the country round his home in Waterdale. Whenever there was a boundary dispute in his county or in the north of the island, it was inevitable that men should call in Jón of Thorormstongue to draw up a scientific map of the district.

All Jón's correspondence was humble and kindly, and I have heard (as I can well believe) that his life and conversation were in accord with his astronomy. His beloved Urania had drawn his thought from all that was vain, mean, foolish, earthly, and had kept him in an attitude of reverent worship towards the great, the sublime, the eternal.

EASTER AND THE ECCLESIASTICAL CALENDAR

By Clarence E. Woodman

THE entire arrangement of the Ecclesiastical Calendar depends upon the date of EASTER DAY. That date was decided by the Ecumenical Council of Nicæa (A.D. 325) to be the Sunday immediately following the first Full Moon—the fourteenth day of the *calendar* moon—happening on or after the VERNAL EQUINOX (March 21).

This Equinox, be it remembered, and this Full Moon, are purely ecclesiastical and arbitrary conventions; and have no definite relation to the actual position of the sun in his apparent orbit, or to the actual phase of the moon in the heavens. The true Vernal Equinox does not always and everywhere fall on March 21, nor nor does the ecclesiastical full moon always coincide with the astronomical one; in fact the latter generally occurs one or two—sometimes three—days earlier than the former. The *ecclesiastical* full moon is supposed to happen at the same instant of local mean time all over the world;—an impossible condition, of course, for the *astronomical* full moon.

A conspicuous example of this discrepancy was seen, for instance, in the year 1905. The Vernal Equinox (*i.e.*, the actual time of the true sun's "crossing the line" of the Equator) occurred at Greenwich, England, at 7 a.m., Tuesday, March 21. It occurred at San Francisco, California, at 11 p.m., Monday, March 20. Similarly the true astronomical full moon for that time of year happened at Greenwich on March 21; at San Francisco it happened on March 20. Had the *real* moon, therefore, been the guide, Easter would have been kept on March 26 at Greenwich, and on April 23 at San Francisco. Whereas the *ecclesiastical* or *Paschal* full moon occurred *everywhere* on Wednesday, April 19; and hence Easter was the Sunday after,—April 23.

Take the case of Easter this very year (1923). The *actual* Full Moon occurred at Greenwich, England, at 1.10 p.m. Sunday, April 1st; (at Toronto, Canada, at 8.10 a.m., and at San Francisco, California, at 5.10 a.m.).

If this true "*astronomical*" Full Moon decided the question, Easter would, according to rule, have been kept on the Sunday *after; i.e.*, on April 8th. But the fourteenth day of the "*ecclesiastical*" Moon occurred on *Saturday, March 31st.* Easter, therefore, was the next day—April 1st.

A perhaps more striking illustration may be given to show the practical impossibility of using the *actual* full moon. Suppose the equinox and the full moon to occur together exactly at midnight according to the local mean time of the meridian passing through, say, Central Park, New York. Anywhere *east* of that line the full moon would fall on the 21st of March; and Easter would be the Sunday after. Anywhere *west* of the line the full moon would fall on the 20th of March; and hence Easter would not happen until the Sunday after the *next* full moon. In other words, the east side of the city would keep one Easter, and the west side another; and they would be a month apart.

The calculation of the date of Easter Day involves the use of the "GOLDEN NUMBER", the "EPACT", and the "DOMINICAL LETTER" of the year in question. The *Golden Number* (so called because marked by golden figures in the calendar) means the particular number which the year bears in the "*Metonic Cycle*" —(discovered by the Athenian astronomer, Meton, in B.C. 432; the first year of the first cycle beginning on June 27th of that year)— a cycle of nineteen years of 235 lunar months, or 6,940 days—(very nearly equal to 19 solar years of 365¼ days each)—at the end of which term the new moon falls on the same day of the year as it did at the beginning. The *Epact* (from a Greek word, meaning "*something added*") shows the *age* of the moon. It is, in any given year, the number of days between the last new moon and the first day of the year. In general, it is the excess of a solar year over a lunar one: a period of about eleven days. The *Dominical* (or *Sunday*) *Letter* indicates on what date the *first Sunday* of the year (and hence any other Sunday) falls. It is one of the first seven letters of the Alphabet. If Sunday falls on January 1, the Dominical Letter is A; if on January 2, it is B; if on January 3, it is C; etc., etc.

Table I is a table of *Golden Numbers*, Table II a table of *Epacts*, and Table III a table of *Dominical Letters*.

The most important reform of the calendar was made at the instance of Julius Cæsar (B.C. 46) by the Greek astronomer, Sosigenes, with the assistance of Marcus Fabius. This calendar, known as the *Julian*, or "Old Style" calendar, restored the equinox —which at that time was nearly two months out of the way—to its proper place; and made the average length of the year 365¼ days. To dispose of this extra quarter of a day, it was determined to intercalate one day every four years; by adding a day to the month of February. As this extra day was obtained by repeating the 24th of February—(or the *sixth* day before the Kalends of March), this 366-day year was called "*bissextile*", or "*twice-sixth-day*" year. Cæsar also named a month after himself: the month that had been called "*Quintilis*" (or "*fifth-month*") was re-christened by him JULY; and he moreover transferred the beginning of the year to January 1. (It had previously been in *March*; as the present names of several of the months show: September, the *seventh* month; October, the *eighth* month; November, the *ninth* month; December, the *tenth* month, for instance.)

As the real length of the tropical or calendar year is 365 days, 5 hours, 48 minutes, and a little over 46 seconds, this Julian term was over eleven minutes too long; and the error amounted to nearly a day in 128 years. In course of time this error of excess became unduly large; so that in the sixteenth century the vernal equinox had changed its place from the 21st to the 11th of March. Hence Pope Gregory XIII, in 1582, issued a Brief abolishing the Julian calendar, and introducing in its stead a new one (invented by Luigi Lilio Ghiraldi, of Verona), and called, after the Pope, the *Gregorian* calendar, or "New Style".

The change was made on the feast of St. Francis of Assisi, October 4, 1582. Ten days were then dropped from the reckoning, and the following day was numbered October 15. The average length of the year was taken to be 365 days, 5 hours, 49 minutes, and 12 seconds (the difference between which and the true length is immaterial: amounting to a whole day in the long lapse of 3,323 years).

In Italy, Spain, Portugal, France, and the Catholic Low Countries, the change was adopted at once. Catholic Germany adopted it the next year. Scotland followed suit in 1600; the rest of Ger-

many, Switzerland, Denmark, Sweden, and the Protestant Low Countries, in 1700; and England and her dependencies in 1752. (It is a matter of record that in England the change met with bitter opposition. Government officials were mobbed on the streets of London by crowds of otherwise sane Britons, hooting and yelling: "Give us back our eleven days!".)

To this day Russia, Greece, Roumania, and the minor nations adhering to the Greek rite, still observe the "Old Style"; but there is a strong sentiment in favour of the adoption of the Gregorian Calendar in Greece.

Many eminent authorities—among them no less an astronomer than Simon Newcomb—have thought the Gregorian calendar no improvement over the Julian one. Professor Newcomb, indeed, recommended a return to the Julian calendar at the beginning of the present century.

DIRECTIONS FOR USING THE TABLES

See first whether the year is an "Old Style" or a "New Style" year. (If it is before 1583, it is *Old Style*; if 1583 or after, it is *New Style*.) If Old Style, make use of Table I; if New Style, use Table II. In either case find the NUMBER at the intersection of the column of the *Century* (*i.e.*, what is left of the date of the year after the last two figures have been dropped off) and the line of the *Year* of the Century (*i.e.*, the last two "dropped-off" figures aforesaid). Find also, in Table III, the LETTER at the intersection of the same Century-column and the same Year-line. Now, keeping this *letter* and *number* in mind, enter Table IV; which has a column of letters, and two blocks of columns of numbers: one set of numbers for Old Style, and the other for New Style. In the block, or section, belonging to the LETTER, and in line with the NUMBER, (being careful to refer this number to its proper column, according to the "Style"), will be seen the dates for the year in question: of Ash Wednesday, Easter Day, Ascension Thursday, Trinity Sunday, and the First Sunday of Advent.

Leap years are distinguished in the Tables by HEAVY type. All "00" *Old Style* years are leap years; in *New Style* such only are leap years as are divisible by 400 without remainder.

TABLE I.

GOLDEN NUMBERS. "OLD STYLE." TO A. D. 1582.

YEAR OF CENTURY	CENTURY															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
00 19 38 57 **76** 95	1	6	11	16	2	7	12	17	3	8	13	18	4	9	14	19
01 **20** 39 58 77 **96**	2	7	12	17	3	8	13	18	4	9	14	19	5	10	15	1
02 21 **40** 59 78 97	3	8	13	18	4	9	14	19	5	10	15	1	6	11	16	2
03 22 41 **60** 79 98	4	9	14	19	5	10	15	1	6	11	16	2	7	12	17	3
04 23 42 61 **80** 99	5	10	15	1	6	11	16	2	7	12	17	3	8	13	18	4
05 **24** 43 62 81	6	11	16	2	7	12	17	3	8	13	18	4	9	14	19	5
06 25 **44** 63 82	7	12	17	3	8	13	18	4	9	14	19	5	10	15	1	6
07 26 45 **64** 83	8	13	18	4	9	14	19	5	10	15	1	6	11	16	2	7
08 27 46 65 **84**	9	14	19	5	10	15	1	6	11	16	2	7	12	17	3	8
09 **28** 47 66 85	10	15	1	6	11	16	2	7	12	17	3	8	13	18	4	9
10 29 **48** 67 86	11	16	2	7	12	17	3	8	13	18	4	9	14	19	5	10
11 30 49 **68** 87	12	17	3	8	13	18	4	9	14	19	5	10	15	1	6	11
12 31 50 69 **88**	13	18	4	9	14	19	5	10	15	1	6	11	16	2	7	12
13 **32** 51 70 89	14	19	5	10	15	1	6	11	16	2	7	12	17	3	8	13
14 33 **52** 71 90	15	1	6	11	16	2	7	12	17	3	8	13	18	4	9	14
15 34 53 **72** 91	16	2	7	12	17	3	8	13	18	4	9	14	19	5	10	15
16 35 54 73 **92**	17	3	8	13	18	4	9	14	19	5	10	15	1	6	11	16
17 **36** 55 74 93	18	4	9	14	19	5	10	15	1	6	11	16	2	7	12	17
18 37 **56** 75 94	19	5	10	15	1	6	11	16	2	7	12	17	3	8	13	18

(It will be noted that in section C of Table IV the number 25 occurs twice—once in HEAVY type in line with 26, and again in ordinary type in line with 24. The rule for deciding which 25 is to be taken is: If the Golden Number of the year is not more than 11, take the 25 in the last line; but if the Golden Number exceeds 11, take the 25 in the first line. Compare, for instance, the years 1886 and 1954. The Dominical Letter of both years is C, and the Epact 25. The Golden Number of the former year is 6; therefore the *last-line* 25 is to be used as the Epact number. But the Golden Number of 1954 is 17; therefore in this case the *first-line* 25 is to be taken. The Easter in the former case is April 25, and in the latter it is April 18.)

EXAMPLE—OLD STYLE: To find the dates of Easter, etc., for the year 1450. In Table I, in the column under 14 and in line with 50, is found the number 7.

TABLE II.

EPACT NUMBERS—"NEW STYLE." FROM A. D. 1583.

YEAR OF CENTURY	CENTURY																														
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
00 19 38 57 **76** 95	19	15	9	4	29	24	19	13	8	4	28	22	18	13	7	2	27	22	17	11	6	2	26	21	16	11	5	0	25	20
01 **20** 39 58 77 **96**	1	26	20	15	10	5	0	24	19	15	9	3	29	24	18	13	8	3	28	23	17	13	7	2	27	22	16	11	6	1
02 21 **40** 59 78 97	12	7	1	26	21	16	11	5	0	26	20	14	10	5	29	25	19	14	9	4	28	24	18	13	8	3	27	22	17	12
03 22 41 **60** 79 98	23	18	12	7	2	27	22	16	11	7	1	26	21	16	10	6	0	25	20	15	9	5	29	24	19	14	8	3	28	23
04 23 42 61 **80** 99	4	29	23	18	13	8	3	28	22	18	12	7	2	27	21	17	11	6	1	26	20	16	10	5	0	25	20	14	9	4
05 **24** 43 62 81	15	10	4	0	24	19	14	9	3	29	23	18	13	8	2	28	22	17	12	7	1	27	22	16	11	6	1	25	20	15
06 25 **44** 63 82	26	21	15	11	5	0	25	20	14	10	4	29	24	19	13	9	3	28	24	18	12	8	3	27	22	17	12	6	1	26
07 26 45 **64** 83	7	2	26	22	16	11	6	1	25	21	15	10	5	0	25	20	14	9	5	29	23	19	14	8	3	28	23	17	12	7
08 27 46 65 **84**	18	13	7	3	27	22	17	12	6	2	27	21	16	11	6	1	25	20	16	10	4	0	25	19	14	9	4	28	23	19
09 **28** 47 66 85	29	24	18	14	8	3	29	23	17	13	8	2	27	22	17	12	6	1	27	21	15	11	6	0	25	21	15	9	4	0
10 29 **48** 67 86	10	5	0	25	19	14	10	4	28	24	19	13	8	3	28	23	17	12	8	2	26	23	17	11	6	2	26	20	15	11
11 30 49 **68** 87	21	16	11	6	0	25	21	15	9	5	0	24	19	14	9	4	28	24	19	13	7	4	28	22	17	13	7	1	26	22
12 31 50 69 **88**	2	27	22	17	11	6	2	26	20	16	11	5	0	26	20	15	9	5	0	24	18	15	9	3	28	24	18	12	7	3
13 **32** 51 70 89	13	8	3	28	22	17	13	7	1	28	22	16	11	7	1	26	20	16	11	5	29	26	20	14	9	5	29	23	19	14
14 33 **52** 71 90	24	19	14	9	3	29	24	18	12	9	3	27	22	18	12	7	1	27	22	16	10	7	1	25	21	16	10	4	0	25
15 34 53 **72** 91	5	1	25	20	14	10	5	29	23	20	14	8	3	29	23	18	12	8	3	27	22	18	12	6	2	27	21	15	11	6
16 35 54 73 **92**	16	12	6	1	25	21	16	10	4	1	25	19	14	10	4	29	24	19	14	8	3	29	23	17	13	8	2	26	22	17
17 **36** 55 74 93	27	23	17	12	6	2	27	21	15	12	6	0	26	21	15	10	5	0	25	19	14	10	4	28	24	19	13	7	3	28
18 37 **56** 75 94	8	4	28	23	17	13	8	2	27	23	17	11	7	2	26	21	16	11	6	0	25	21	15	9	5	0	24	19	14	9

TABLE III. DOMINICAL LETTERS

YEAR OF CENTURY																	CENTURY						
																O.M. Style / N.S. Style	0 7 14 17 21 25 29 33 37 41*	1 8 15	2 9 16 18 22 26 30 34 38 42*	3 10 17	4 11 15 19 23 27 31 35 39 43*	5 12 16 20 24 28 32 36 40 44*	6 13
																	The this column till 1582. From 1583 to 1599 use column 5.						* And so on, every four centuries.
00	06		17	23	**28**	34		45	51	**56**	62		73	79	**84**	90		C	D	E	F	G	A	B
01	07	**12**	18		29	35	**40**	46		57	63	**68**	74		85	91	**96**	B	C	D	E	F	G	A
02		13	19	**24**	30		41	47	**52**	58		69	75	**80**	86		97	A	B	C	D	E	F	G
03	**08**	14		25	31	**36**	42		53	59	**64**	70		81	87	**92**	98	G	A	B	C	D	E	F
	09	15	**20**	26		37	43	**48**	54		65	71	**76**	82		93	99	F	G	A	B	C	D	E
04	10		21	27	**32**	38		49	55	**60**	66		77	83	**88**	94		E	F	G	A	B	C	D
05	11	**16**	22		33	39	**44**	50		61	67	**72**	78		89	95		D	E	F	G	A	B	C

TABLE IV. CHURCH DATES.

LETTER	GOLDEN NUMBER OLD STYLE	EPACT NUMBER NEW STYLE	ASH WEDNESDAY*	EASTER DAY	ASCENSION DAY	TRINITY SUNDAY	ADVENT SUNDAY
A	3 6 11 14 17 1 4 9 12 7 10 15 18 2 5 13 16 8 19	28 29 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27	Mar. 1 Feb. 22/23 " 15/16 " 8/ 9 Mar. 8	Apr. 16 " 9 " 2 Mar. 26 Apr. 23	May 25 " 18 " 11 " 4 June 1	June 11 " 4 May 28 " 21 June 18	Dec. 3 " 3 " 3 " 3 " 3
B	3 6 11 14 1 9 12 17 4 7 10 15 18 2 5 13 16 8 19	27 28 29 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26	Mar. 2 Feb. 23/24 " 16/17 " 9/10 Mar. 9	Apr. 17 " 10 " 3 Mar. 27 Apr. 24	May 26 " 19 " 12 " 5 June 2	June 12 " 5 May 29 " 22 June 19	Nov. 27 " 27 " 27 " 27 " 27
C	3 11 14 19 1 6 9 12 17 4 7 15 18 2 5 10 13 16 8	25 26 27 28 29 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25	Mar. 3 Feb. 24/25 " 17/18 " 10/11 Mar. 10	Apr. 18 " 11 " 4 Mar. 28 Apr. 25	May 27 " 20 " 13 " 6 June 3	June 13 " 6 May 30 " 23 June 20	Nov. 28 " 28 " 28 " 28 " 28
D	3 8 11 14 19 1 6 9 17 4 7 12 15 18 2 5 10 13 16	24 25 26 27 28 29 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	Mar. 4 Feb. 25/26 " 18/19 " 11/12 " 4/ 5	Apr. 19 " 12 " 5 Mar. 29 " 22	May 28 " 21 " 14 " 7 Apr. 30	June 14 " 7 May 31 " 24 " 17	Nov. 29 " 29 " 29 " 29 " 29
E	6 9 14 17 1 4 7 12 15 2 10 13 18 5 16 3 8 11 19	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 0	Feb. 26/27 " 19/20 " 12/13 " 5/ 6 Mar. 5	Apr. 13 " 6 Mar. 30 " 23 Apr. 20	May 22 " 15 " 8 " 1 " 20	June 8 " 1 May 25 " 18 June 15	Nov. 30 " 30 " 30 " 30 " 30
F	3 6 9 14 17 1 4 12 15 2 7 10 13 18 5 16 8 11 19	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29	Feb. 27/28 " 20/21 " 13/14 " 6/ 7 Mar. 6	Apr. 14 " 7 Mar. 31 " 24 Apr. 21	May 23 " 16 " 9 " 2 " 30	June 9 " 2 May 26 " 19 June 16	Dec. 1 " 1 " 1 " 1 " 1
G	3 6 14 17 1 4 9 12 15 2 7 10 18 5 13 16 8 11 19	29 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28	Feb. 28/29 " 21/22 " 14/15 " 7/ 8 Mar. 7	Apr. 15 " 8 " 1 Mar. 25 Apr. 22	May 24 " 17 " 10 " 3 " 31	June 10 " 3 May 27 " 20 June 17	Dec. 2 " 2 " 2 " 2 " 2

*In Leap Years take the second date

In Table III, in the column under 14 and in line with 50, is found the letter D. In Table IV, in section D and in line with 7 (Old Style column) are found the dates: Ash Wednesday, Feb. 18; Easter Day, Apr. 5; Ascension Day, May 14; Trinity Sunday, May 31; and Advent Sunday, Nov. 29.

NEW STYLE: To find the dates of Easter, etc., for the year 1928. In Table II, under 19 and in line with 28, is the number 8. In Table III, under 19 and in line with 28, is the letter G. In Table IV, in section G and in line with 8 (New Style column) are the dates: Ash Wednesday, Feb. 22 (the *second* date is taken because 1928 is a leap year); Easter Day, Apr. 8; Ascension Day, May 17; Trinity Sunday, June 3; and Advent Sunday, Dec. 2.

Knowing the Dominical Letter of any given year (as found in Table III), it is easy to ascertain, by means of the following Table, the *Day of the Week* on which any date falls.

To do this, look along the line of the month until the Dominical Letter of the year (as given in Table III) is found. (For dates in January and February in *Leap Years* take the line in which those months are printed in CAPITAL letters.) In the column under the Dominical Letter will be found the order of Week Days corresponding to the various dates of the month, as set forth on the left-hand side of the Table.

TABLE OF DAYS OF THE WEEK

MONTH.	DOMINICAL LETTER.						
Jan. Oct.	A	B	C	D	E	F	G
Feb. Mar. Nov.	D	E	F	G	A	B	C
JAN. Apr. July	G	A	B	C	D	E	F
May	B	C	D	E	F	G	A
June	E	F	G	A	B	C	D
FEB. Aug.	C	D	E	F	G	A	B
Sept. Dec.	F	G	A	B	C	D	E
1 8 15 22 29	Sun	Sat	Fri	Thu	Wed	Tue	Mon
2 9 16 23 30	Mon	Sun	Sat	Fri	Thu	Wed	Tue
3 10 17 24 31	Tue	Mon	Sun	Sat	Fri	Thu	Wed
4 11 18 25	Wed	Tue	Mon	Sun	Sat	Fri	Thu
5 12 19 26	Thu	Wed	Tue	Mon	Sun	Sat	Fri
6 13 20 27	Fri	Thu	Wed	Tue	Mon	Sun	Sat
7 14 21 28	Sat	Fri	Thu	Wed	Tue	Mon	Sun

EXAMPLE—OLD STYLE: On what day of the week did October 14, 1066 (Battle of Hastings) fall? The letter at the intersection of column 10 and line 66, in Table III, is A. That letter occurs in the October line in the above Table in the first column. In that column, in line with 14, is SATURDAY.

NEW STYLE: What day of the week was June 18, 1815 (Battle of Waterloo)? The letter (in Table III) corresponding to column 18 and line 15 is A. In the June line of the "Days-of-the-Week" Table this letter A is in the fourth column. In line with 18 in that column is found SUNDAY.

These Tables can be used in an inverse sense: *i.e.*, to find the date, or dates, corresponding to any particular day of the week.

EXAMPLE—How many "unlucky Fridays" (supposedly Fridays falling on the 13th day of the month) will there be in 1925? The letter for 1925 (Table III) is D. Friday, in the Days-of-the-Week Table, occurs in line with 13 in the first column. D, in that column, is in line with February, March and November. Friday, therefore, will happen on the 13th three times that year—in the months mentioned.

The following is a convenient method of finding the day of the week; and one easily memorized; dispensing with Tables:

A. Add together:
1. The number of the *year* (*i.e.*, the *last two* figures of the date).
2. One-fourth of this number (disregarding the remainder).
3. The number of the day of the month.
4. The number in the following series, according to the month.

JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.*
6	2	1	4	6	2	4	7	3	5	1	3

B. Now take the number of the *Century* (*i.e.*, the figure, or figures, left after the last two figures have been cut off). If Old Style, subtract this number from the next higher multiple of 7. If New Style, divide this number by 4, and subtract twice the remainder from 9. In either case add the result to the sum previously found.

C. Divide the total by 7. The remainder shows the day of the week: 1 = Sunday; 2 = Monday; 3 = Tuesday; 4 = Wednesday; 5 = Thursday; 6 = Friday; and 7 (or 0) = Saturday.

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*The following bit of unpublished natural history may be useful as an aid to memorizing these figures, and their sequence:

"Fat Bears At Dawn Feel Bold; Dark Gray Cats' Ears Are Cold."
(The numerical position in the Alphabet of the first letter of each word shows the figure belonging to the corresponding month.)

EXAMPLE:

OLD STYLE:	
Oct. 14th, 1066. Battle of Hastings	
Number of year	=66
Fourth part	=16
Day of Month	=14
Number for Month	= 5
	101
Number of Century (10) subtracted from 14	= 4
	7)105
	15
Remainder = 0 = SATURDAY	

NEW STYLE:	
June 18th, 1815. Battle of Waterloo	
Number of Year	=15
Fourth Part	= 3
Day of Month	=18
Number for Month	= 2
	38
Twice Remainder, after dividing number of Century (18) by 4 = 4. This subtracted from 9	= 5
	7) 43
	6
Remainder = 1 = SUNDAY	

(NOTE—For dates in January and February, the *year before* must be taken.)

There are three other special terms sometimes met with in connection with ecclesiastical computations, though they have no bearing on the present matter, the "SOLAR CYCLE", the "PASCHAL CYCLE", and the "INDICTION". The first two are peculiar to the Julian calendar. The former is a period of 28 years; after the lapse of which the days of the week recur on the same days of the month; and is regarded as having commenced nine years before the Christian Era. The latter is a period of 532 years; at the end of which Easter falls on the same day of the year. The "Indiction"—often used in dating pontifical documents—was established by Constantine the Great; as a period during which taxes (readjusted at the beginning of the period) could be paid. It shows the place of the year in a cycle of 15 years, counting from A.D. 313. The rules for these are as follows:

1. *Solar Cycle:* Add 9 to the date, and divide by 28. The quotient is the number of elapsed cycles; and the remainder is the year of the cycle. If there is no remainder, the cycle-year number is 28.

2. *Paschal Cycle:* Divide the date by 532. The remainder is the place of the year in this cycle.

3. *Indiction:* Add 3 to the date, and divide by 15. The remainder is the number of the Indiction. If there is no remainder, the Indiction is 15.

The following table of Old Style *Epacts* corresponding to the *Golden Numbers* of the Julian years may be found useful:

Golden No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Epact	11	22	3	14	25	6	17	28	9	20	1	12	23	4	15	26	7	18	29

Another method of calculating Easter (Gauss, *Band* 6, *Seite* 73), —applicable to both Old and New Styles—is as follows:

1. Divide the whole date by 19, and call the remainder A.
2. Divide the whole date by 4, and call the remainder B.
3. Divide the whole date by 7, and call the remainder C.
4. Divide 19A+X* by 30, and call the remainder D.
5. Divide 2B+4C+6D+Z* by 7, and call the remainder E.

Then Easter is the (22+D+E) of March, or the (D+E−9) of April.

There are two exceptions to this rule:

1. When the calculated Easter would fall on April 26th, put it back to the 19th.

2. When it would fall on April 25th, put it back to the 18th (if A is more than 10, and D is 28).

TABLE OF CENTURY CONSTANTS.

Years	X	Z	Years	X	Z
All "Old Style" years	15	6	From 3000 to 3099	28	6
From 1583 to 1699	22	2	" 3100 " 3299	29	0
" 1700 " 1799	23	3	" 3300 " 3399	29	1
" 1800 " 1899	23	4	" 3400 " 3499	0	2
" 1900 " 2099	24	5	" 3500 " 3599	1	3
" 2100 " 2199	24	6	" 3600 " 3699	0	3
" 2200 " 2299	25	0	" 3700 " 3799	1	4
" 2300 " 2399	26	1	" 3800 " 3899	2	5
" 2400 " 2499	25	1	" 3900 " 4099	2	6
" 2500 " 2599	26	2	" 4100 " 4199	3	0
" 2600 " 2699	27	3	" 4200 " 4299	3	1
" 2700 " 2899	27	4	" 4300 " 4499	4	2
" 2900 " 2999	28	5			

EXAMPLE—What, as calculated by this rule, are the dates of Easter for the years previously cited: (*i.e.*, 1450 and 1928?).

*X and Z are special constants; to be employed as shown in the "Table of Century Constants" above.

1. The Old Style Year, 1450

19)1450
76 Remainder (A) =6
4)1450
362 Remainder (B) =2
7)1450
207 Remainder (C) =1
19A=114
+15 (X)
30)129
4 Remainder (D) =9
2B = 4
4C = 4
6D =54
+ 6 (Z)
7)68
9 Remainder (E) =5

Easter is then the
9+5−9 of April=Apr. 5

2. The New Style Year, 1928

19)1928
101 Remainder (A) = 9
4)1928
482 Remainder (B) = 0
7)1928
275 Remainder (C) = 3
19A=171
+ 24 (X)
30)195
6 Remainder (D)=15
2B = 0
4C =12
6D =90
+ 5 (Z)
7)107
15 Remainder (E)=2

Easter is then the
15+2−9 of April=Apr. 8

Both of these results agree with those shown by the Tables, as shown above.

The foregoing method is subject, like similar ones, to certain exceptions. The following, while somewhat longer, admits of no exceptions:—

1. Divide the year by 19, and call the remainder A.
2. Divide the year by 100, and call the quotient B, and the remainder C.
3. Divide B by 4, and call the quotient D, and the remainder E.
4. Divide $(B+8)$ by 25, and call the quotient F.
5. Divide $(B-F)+1$ by 3, and call the quotient G.
6. Divide $(19A+B+15)-(D+G)$ by 30, and call the remainder H.
7. Divide C by 4, and call the quotient I, and the remainder K.
8. Divide $(2E+2I+32)-(H+K)$ by 7, and call the remainder L.
9. Divide $(A+11H+22L)$ by 451, and call the quotient M.
10. Divide $(H+L+114)-7M$ by 31, and call the quotient N, and the remainder P.

Then N is the *Month*, and $(P+1)$ the *Day of the Month*, on which EASTER falls.

EXAMPLE: To find the date of Easter in the year 1930:—

(1)	(2)	(3)
19)1930(101	100)1930(19, quot. B	4)19(4, quot. D
19	100	16
30	930	3, rem. E
19	900	
11, rem. A	30, rem. C	

(4)
25)27(1, quot. *F*
25
—
2

(5)
3)19(6, quot. *G*
18
—
1

(6)
30)233(7
210
—
23, rem. *H*

(7)
4)30(7, quot. *I*
28
—
2, rem. *K*

(8)
7)27(3
21
—
6, rem. *L*

(9)
451)396(0, quot. *M*

(10)
31)143(4, quot. *N*
124
—
19, rem. *P*

EASTER, then, is the (19+1) DAY of the 4th MONTH; *i.e., April 20th.*

Similarly we find for the year 2000: $A=5$; $B=20$; $C=0$; $D=5$; $E=0$; $F=1$; $G=6$; $H=29$; $I=0$; $K=0$; $L=3$; $M=0$; $N=4$; $P=22$. EASTER, therefore, is the *23rd of April.*

Easter cannot possibly fall earlier than *March* 22 (which has not happened since 1818, and will not happen again till 2285), or later than *April* 25, (which happened last in 1886, will happen in 1943, and not again till 2038). This earliest date ocurs when the Paschal Full Moon falls on the same day as the Vernal Equinox, and that day is SATURDAY. Easter is then the Sunday immediately following. The latest date occurs when the Paschal Full Moon falls on April 18, and that day is SUNDAY. Easter then comes the Sunday after.

It may be of interest to mention that although one object which the Fathers of the Nicene Council had in mind in arranging the *Calendar Moon* was that Easter might never fall on the same day as the *Jewish Passover*; as a matter of fact these two Festivals *did* occur together: in 1805 (on the 14th of April); and again in 1825 (on the 3rd of April); and again in 1903 (on the 12th of April). The same coincidence will also occur this year, 1923 (on the 1st of April); and in 1927 (on the 17th of April); and in 1981 (on the 19th of April). The Passover always precedes the Jewish New Year by 163 days; and that New Year falls on, or immediately after, the New Moon following the Autumnal Equinox. The date

of the Jewish New Year may be found by subtracting the Gregorian *Epact* (see Table II) from September 24 in an ordinary year, and from October 24 in an "embolismic"* one.

Notwithstanding the large and ever-growing difference between the Julian and the Gregorian reckoning (amounting now to 13 days, and increasing at the rate of 3 days every 400 years), Easter "Old Style" and Easter "New Style" have fallen on the same day no less than 130 times since the reformation of the calendar in 1582. The first coincidence was in the very next year, 1583 (April 10), and the latest in 1906 (April 15). From now on there will be 142 more of these concurrences, at longer and longer intervals (up to, and including, April 24, 2698); after which they can never occur again.

Error of the Gregorian Calendar: In carrying out his reform of the then existing calendar the chief motive of Pope Gregory XIII seems to have been to restore the Feast of Easter to the epoch fixed by the Council of Nicæa. His dropping out of sight the ten days after Thursday, the 4th of October, and calling the next day Friday, the 15th of October, was evidently based on the supposition that the dates of the Nicæan Council (A.D. 325) were exact.

But if the calculations of Sosigines *et al.* were correct in B.C. 46, such could not have been the case. The *centurial* years (100, 200 and 300), which were *Leap Years* under the Julian system, ought not to have been such according to the Gregorian rule. Between B.C. 46 and A.D. 325, therefore, there were some three more days than (by Gregorian standards) there should have been; as follows:

As the Julian Calendar makes it, these 370 years contained:
370×365.25 (length of Julian year) $= 135142.5$ days.
But by Gregorian reckoning they should have contained:
370×365.2425 (length of Gregorian year) $= 135139.725$ days.
A difference of 2.775 days.

Hence, in strict adherence to the Gregorian system, our present dates are nearly three days behindhand. The first of January this year, for instance, should have been called the *fourth*, and so on.

Newman Hall, University Catholic Chapel,
Berkeley, California.

*An "embolismic" year is one that contains an intercalary month ("*Veadar*") of 29 days. The rule for determining such a year is: Multiply the number of the Jewish year (obtained by adding 3761 to the Christian year) by 7 and add 1. Divide this result by 19. If the remainder is less than 7, the year is *embolismic*.

AUSTRALIAN ABORIGINAL ASTRONOMY

By J. G. Griffin

IT is, of course, but a twice-told tale, to repeat that from a time too remote to be known, the heavens have been conventionally divided into fabulous groups consisting of stars which record the poetry, the religious symbols, the heroic deeds, no less than the baser passions of peoples whose very names have perished; but, so long lived is legend, so forceful is habit, that, wherever throughout the world civilized men now watch the skies, they still conform to these same picturesque if unmeaning figures and designations. It was the Greeks of old—

> "the radiant people
> That ever enraptured the world with dreams of melodious grace,"—

who, embellishing with a richer and more varied imagery the traditions brought to them from a distant age, have founded a universal language for the most delightful as it is the least selfish of all the sciences. But the Greeks and their forerunners were not the only mortals to see visions and dream dreams. All savage communities have had and still have legends concerning the people, animals and what not which they assume to find amongst the stars. The Australian aboriginals hold several such, and, better than all the rest, they possess the singular distinction of being the only people who have imagined a black constellation. This is called by them and now by us, perhaps somewhat derisively, the constellation of the Emu. Most people know that in Australia there is a large ratite bird, the *Dromaeus novae hollandiae*, called generally "Emu", which is said to be the name given to it by the natives when the first European settlers questioned them, but which does not occur in any of the myths concerning the bird with which the writer is acquainted. Sometimes it is incorrectly called a cassowary. It is of very dark-grey, almost black, hair-like plumage, with a small head, long neck, high and powerful legs, three-toed feet and short useless wings, and is now being gradually extinguished in the more settled districts of our island continent.

The so-called constellation may be clearly seen in the southern skies from March to May on a moonless night. It is chiefly composed of the dark nebulous formation known as the "Coal Sack" close to the Southern Cross, which represents the body of the bird; from it there are several wisps and lanes of opaque matter which twine and twist in and about the Milky Way in that region of the sky, and these form the slender neck and long legs of the figure. Some imagination is of course required to make it out, but not more than is necessary when tracing many another group in the northern hemisphere.

The Emu, *i.e.*, the bird itself, has various designations amongst the natives, but in that portion of Australia from whence the following legend comes, is known as *Tchingal*.

On one occasion Tchingal was roaming about looking for food and came across an opossum (*Banya*) doing the same thing. Banya had a bundle of spears in his hands which he used for killing such smaller animals or birds as he wanted. When Tchingal saw Banya he immediately gave chase and the latter, impeded by his weapons, was being quickly overtaken, when, casting the spears at the foot of a large tree, he ran up its trunk to a branch beyond Tchingal's reach. Suddenly two natives, noted hunters, who had watched what was going on, seizing Banya's spears, set upon Tchingal and killed him. The King of heaven, who was also an onlooker, now exercised his supernatural powers and caught both Tchingal and Banya up into the sky, making the former's body the coal sack and his long legs the black streams which spread from it through the Galaxy thereabouts. The points of the spears which killed Tchingal are Alpha and Beta Crucis, one passes through his neck and the other through his thighs. Banya was transformed into Gamma Crucis and thus can forever watch his enemy should he again try to capture him.

The Origin of the Sun

M. Arnold van Gennep in his "Mythes et Légendes D'Australie",—an excellent collection from various authors—says: "Dans toute l'Australie le soleil est une femme" (In all Australia the sun is a female). This is certainly the case, and a diligent search in every available direction confirms the statement. There

are several accounts of the birth of the sun, of which the following is one of the clearest.

Before men existed the earth was in darkness except for such light as the stars and moon afforded, for the latter preceded the sun. There were however plenty of animals, birds and fishes, most of whom lived in a perpetual state of quarrelling and fighting one with the other for food, which, then as now, was difficult to procure. One such trouble arose on the Murrumbidgee plain between Dinewan (the Emu) and Bralgah (the Native Companion, the largest Australian crane—*Grus Australasianus*). Dinewan had laid an egg in her nest on the ground, which Bralgah, who had been watching, by some stratagem managed to steal. He flew away with it and going right up into the sky placed it upon a heap of fire-wood in the form of a woman and called by the natives Gnowee, which by some unexplained process had there been collected. The contact of the egg with the heap caused the latter to burst into flame, thus giving, for the first time, light in daytime to the world. The King of heaven, sometimes called *Nugurundere*, was so pleased with this that he ordered his attendants to go forth and gather wood in every direction, that the fire might be kept up, but he commanded them only to light it in the mornings when a bright star appeared in the east. He also warned the animals on earth to look out for the star, that they might know when the heap was about to be lit. Most of them were too lazy to do this, and another expedient occurred to Nugurundere. There is in Australia a bird, familiar to everyone and known as the laughing-jackass, from the peculiar shrill and loud note he makes when singing. He is known as the kookuburra (*Dacelo gigas*) and is one of the king-fishers, but is better remembered by his habit of killing snakes. The King of heaven determined to make use of kookuburra's song and told him that, just as the star was appearing, he was to make as much noise as he could so that there should be no excuse for the birds and animals not being "up and doing" when the big light appeared. Kookuburra of course obeyed and thus the animals had no excuse for laziness.

In the early morning, when first the heap is set afire, the heat is not great, but as noon approaches and the main body is alight it becomes so fierce that none of the animals can move in the open;

towards evening, as the wood is consumed, coolness and darkness gradually prevail and so they can again go forth for food. Shortly after this the Daens, *i.e.*, the aboriginals, appeared on earth, and were told never to permit their children to copy the voice of kookuburra, especially at night-time, for fear of creating a false presage of dawn. Should they do so, however, darkness would again envelop the world and they would themselves be punished by the growth of a large tooth above their ordinary teeth, which would for ever be a mark of their disobedience !

The Moon

It is clear that the moon has always been looked upon as a man by the Australian natives, with the single exception of the Narrinyerri tribe in the Encounter Bay district, who describe her as a woman and one of no particular virtue. For many days she remained amongst men, but the hardships she suffered reduced her to a mere skeleton. The King of heaven, Nurrunduri (compare Nugurundere in the myth of the sun), becoming angry with her for her misbehaviour and disliking her attenuation, ordered her to be driven away. She flies and for some days is secreted, but while hidden is really digging roots of a marvellously nourishing character, from the consumption of which she gradually fills out and becomes fat again. While thus improving in condition she now and then shows herself for part of the night and ultimately, when her complete strength has been regained, for the whole night as the full moon. Soon afterwards she falls away and little by little relapses into her old forlorn life.

There would seem however to be another reason for the King of heaven's treatment of the moon. He (for now Luna is transformed in gender) was originally a native-cat called Mityan (*Dasyurus Geoffroyi*) who fell in love with Unurgunite's wives (observe that the name of the King is essentially the same with some slight alteration, due probably to the ears of the recorders!) and while endeavouring to induce her to run away with him is discovered by Unurgunite. A great fight follows, ending in the defeat of Mityan, who, unable to find repose anywhere has been kept wandering about the sky ever since as the moon.

In the Northern territory of Australia the aborigines consider that in the ancient times (called by them Jabulunga) the moon was a man named sometimes Kandanuk and sometimes Murtgijina. For many years he lived in a great cave on the side of a mountain far away to the west of a district known as Laguning. When he died his spirit, and that of an old kangaroo (inumbe go) which he owned and of three of his hunting dogs were translated into the sky and became the moon, in which, at the full, you can see the old fellow and his associates. The full moon is called by these people Igul, the half moon Idadad and the new or crescent Wurdu. Moonrise is Ijumna, moon set Yagadjun. The spirit of a living man is called Yibi, of a dead man Yungeba.

Another account of the legend is held by people called the Larrikia tribe at Port Darwin, North Australia. Nanganburra lives in the bowels of the earth and is the originator of all the blacks, who, when they die go to his abode. If they have behaved properly, he gives them a pass to Mangarrara with whom they live among the stars. On the other hand, the wicked are sent to the interior of the earth to a place called Omar where there is always a large fire burning. Deep below the fire is a great lake called Burcoot, where an immensely powerful black always lives. His name is Madjuit-madjuit. He is a friend of Mangarrara and regulates the tides (they rise 40 feet at Port Darwin) by means of the moon, which never dies. In another part of Australia, where the natives had become impoverished, there was born of a virgin a good and wise man called Wyungare who gave them weapons and taught them sorcery. After a time Wyungare dies and is taken to Heaven where he becomes the second greatest person and shines as the moon.

It will at once occur to the reader that the two myths have a close connection with European knowledge and tradition. The great rise in the tides at Port Darwin may have caused the early English settlers to tell the blacks that the moon was working well and thus they fortified their old story by including his (for he was a male to them) power regarding the heaped-up waters. The second allusion, that to the virgin-birth, could easily have been derived from early missionaries, possibly from either the Dutch or Spaniards who were in these waters long before the English.

The Pleiades

As with the Greeks so with the Australian aborigines the Pleiades are favourite objects upon which to frame a story, and are always considered to be seven young women. There are many variants of this myth, one of the most complete being that held by a tribe in Riverina called Noongaburrah. It seems that a man named Wurrannah, flying from a hostile party whom he had injured in some way, came to a camp where seven sisters dwelt, whose tribal name was Meamei. They were hospitable, gave him food and drink and allowed him to remain in their camp that night. Next morning he said he would go on his journey, but, having made up his mind to get one or two of them for wives, hid in the dense scrub hard by until the girls had left camp. The blacks are very fond of ants' eggs and the Meamei girls were provided with specially shaped sticks to enable them to dig out both yams and the ants' nests and secure the ants' eggs. This they proceeded to do, working away in the soil until midday. Then carelessly throwing their sticks down in the open they trailed off to the shade of some large trees and made a meal of what they had secured and then, *sine mora*, slept the sleep of the just. Wurrannah knew their habits, and when they were sleeping took two of the sticks and made off with them. Towards evening the seven, walking over to take up their tools, could find only five. The five girls who each claimed one, took them and returned to the camp, leaving two behind to search for those that were missing. Wurrannah had fixed these two sticks firmly in the ground at some distance away, but the girls soon saw where they were and rushed off to take them home. However Wurrannah had taken the precaution of hammering the sticks so tightly into the ground that the poor girls strove in vain to move them, and while they were thus struggling, he came along and captured them both, and ordered them to accompany him as his wives. Grieved at the loss of their sisters and weak and powerless, they were compelled to obey, and after the manner of the blacks, became his beasts of burden and the providers of his food. Upon one occasion, after there had been a heavy fall of rain making everything moist, he directed them to light a fire and cook some flesh. They tried to do so but everything was so damp

that the fire would not burn. Grumbling at the delay he ordered them to obtain some of the bark of neighbouring pine trees and thus make a blaze. "No," said the two, "if we cut pine bark you will never see us again." "Go and do as I tell you," he cried. "Well," they replied, "if we do you will lose us." "Go!" he shouted, "and don't talk!" Each girl, then, taking a combo (a stone tomahawk), selecting a couple of trees close together, drove their combos simultaneously into them. Hardly had they done so when the trees began to rise out of the ground taking the girls with them. No screaming or ordering that Wurrannah indulged in was of any avail, for the trees gradually ascended higher and higher until they reached the sky. Upon touching the blue vault the two girls were surprised and rejoiced to hear their five sisters calling to them, and when they answered, the five sisters thrust out their hands and pulled them from the trees and gathered them into their arms. The seven reunited Meamei remained in heaven and can be seen as the Pleiades to this day.

A variant of this is, that the Pleiades are a group of young girls called Karat (group) Goruk (female) who were digging up ants' eggs with their yam sticks, at the ends of which Wearg, the crow, had fixed some live coals of fire that he had stolen for them. Bellin-bellin (the musk-crow) at the command of Bunjil, the great father of all, who was very angry at this, opened a large bag he always possessed, and sent out a great whirlwind. This swept the girls right into heaven where they remain as the Pleiades, still carrying fire at the ends of their yam-sticks.

The latest account of the Pleiades myth has come this year from Mrs. D. M. Bates, who lives and is the Commonwealth principal in charge of an aboriginal camp at a place called Oldea on the edge of the Nullabor* Plains. Her home is some distance north of the long East-West railway between Perth and Adelaide, a few hundred miles away from the head of the Great Australian Bight. From her account of the manners, habits, ideas and legends of these natives the following is gathered. The Ming-arri are a flock of small animals known as the mountain devils, quite harm-

*Nullabor—an enormous treeless plain 10,000 square miles in extent. The name is said to be derived from the Latin for "no tree" (*nulla arbor*) but the writer thinks it is of aboriginal derivation.

less little creatures. They were supposed to be all women who lived by themselves and refused to have anything to do with men. In order to keep to themselves they kept a pack of dingoes (the native dog, *canis dingo*) who killed and ate most of the men and drove away the rest, who attempted to reach the Ming-arri. Nyiruna was a great hunter in those days, who desired to obtain the Ming-arri for his wives. He left food for them and tried in many ways to tempt them to come to him, but was always prevented by the dogs from doing so. He pestered the women so greatly that by some means both he and they were translated to the sky. They became the Pleiades and Nyiruna was turned into a star and in the shape of Orion continually chasing the Ming-arri, but never overtaking them.

Another curious tale of the Pleiades comes from the extreme north of Australia. In York Peninsula the sisters still compose this cluster, but one of them, the faintest of the seven, came down to earth and married an aboriginal named Canggoolgeenya but was brought back to heaven by her father, the large star Alcoling-ga, probably Aldebaran. As if ashamed of her behaviour she continually tries to hide and is thus the faintest of the seven. This Professor A. Metson, who narrates the myth, deems nearly identical with the Greek legend, to which it certainly has some resemblance.

BIBLIOGRAPHY

Proceedings of the Royal Society of N.S.W. Transactions of the Philosophical Society of Victoria. Mrs. D. M. Bates, "The Great Plain's Edge". Mrs. K. Langtoh Parker, "Australian Legendary Tales". Professor A. Metson, "Outdoor Australia". Arnold van Gennep, "Mythes et Légendes d'Australie". Rev. Taplin, "Aboriginal Folk Lore". A. W. Howitt, "Five Tribes of S.-E. Australia". Brough Smyth, "Aborigines". Baldwin Spencer, "Native Tribes of Northern Australia". Carr, "The Australian Race", etc.

Carlton, near Sydney, N.S.W.

REVIEW OF PUBLICATIONS

Etudes Elémentaires de Météorologie Pratique, par Albert Baldit, Ancien chef du Service Météorologique d'un groupe d'Armées, Président de la Commission Météorologique de la Haute-Loire. 2nd edition, revised and enlarged. 340 pages, 8vo, with 118 figures. Paris, Gauthier-Villars, 1923, price 24 francs.

Basing his conclusions largely on the very effective meteorological organization which was in operation in the fighting zone during the war, the author outlines what he considers to be an ideal Meteorological Service both as regards general administration and the equipment of stations of the various classes, including a Central Bureau, regional stations, and secondary stations.

M. Baldit while admitting that climatological statistics are important, considers that meteorological observations should be studied with special relation to definite atmosphere distribution. He would study the nature of the clouds which belong to various barometric changes, their formation and dispersal. In place of merely recording temperatures he would examine their relationship to the particular formations which the daily weather chart shows and their bearing on cloudiness, precipitation and storms.

The meteorologist placed in charge of each section of the service should know all its local peculiarities. His station should be a lookout post gathering the smallest atmospheric facts and constantly making them useful for the purposes of meteorology. He should unite with the special qualities of those who devote themselves to the physics of the globe, qualities of physical activity, and of endurance and decision.

Meteorology should have a stimulus which gives all the researches an immediate interest, excites and co-ordinates them, and he thinks this is best supplied by the weather map on which forecasts are based.

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The book is separated into two volumes. In Volume I. is given a very excellent description of the organizations of the various sections of a meteorological service, including upper air research by means of pilot balloons, registering balloons and the aeroplane.

In Volume II. the various problems in connection with meteorological research and forecasting the weather are most ably discussed and a very clear idea is conveyed concerning the methods now in vogue in the Meteorological Service of France; Chapter XVI., on nocturnal radiation and the prediction of the minimum temperature, is particularly interesting, and Chapter XVII., on "Rules for the prediction of the weather..." will, we think, be very helpful to professional meteorologists and to amateurs who wish to become weatherwise.

R. F. STUPART.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

The Journal of the Astronomical Society of South Africa

It is with especial pleasure that we welcome Vol. I., No. 1, of the above publication, which bears the date February, 1923.

Some ten years ago a meeting was called at the old Town House in Cape Town with a view to the formation of a local astronomical association for the purpose of encouraging the study of astronomy and disseminating astronomical information among its members. The outcome was the formation of the Cape Astronomical Society, which has since continued to further these objects "by the holding of monthly meetings of its members for the reading of papers and discussions, by the promotion and organization of lectures and the formation of observing sections, and by the mutual help of its members in affording one another access to such astronomical telescopes as are in their possession".

One of the Society's members, Mr. Reid, has discovered three comets and another member has discovered one. Besides, much useful work has been done on meteors and variable stars. One of the members contributes a monthly column in the press, and the papers and discussions at the monthly meetings have proved useful and interesting.

In 1918 the Johannesburg Astronomical Association was founded, but in July, 1922, the two bodies were merged into the Astronomical Society of South Africa with a Cape "Centre" and a Johannesburg "Centre". This recent development is particularly interesting to the present writer, who likes to think that he has been in some degree responsible for the chain of "Centres" stretching across our own Dominion. The first president of the new Society is Mr. S. S. Hough, H.M. Astronomer at the Cape, and in the first number of the *Journal* his inaugural address is printed.

On behalf of the Royal Astronomical Society of Canada and also personally, the present writer wishes to send greetings to the Astronomical Society of South Africa and to wish it a long and useful career.

The Sun and Our Recent Winter

At a recent meeting at Washington Dr. C. G. Abbot, our great authority on the measurement of solar radiation, made the statement that in recent months the output of heat from the sun had shown a diminution of four or five per cent. Now in various parts of the United States and Canada the general impression is that the past winter was one of exceptional severity. In Toronto there was more snow than usual, and several periods of decidedly cold weather led many of the citizens to believe that the winter as a whole was distinctly colder than the average. At once there comes the suggestion that the sun's diminution would produce just such a state of affairs. But reports state that in England the winter was mild, and that at some places in our north-west provinces it was not so cold as usual. Further, letters from Australia bring the information that there was no lack of heat down there. And then, to add to all this, one of our newspapers published an article by Sir Frederic Stupart, the director of the Meteorological Service of Canada, in which it is declared that the recent winter was not abnormally cold after all. Sir Frederic's statement contains so many interesting facts that it is given in full.

There is certainly a very general impression that the past winter in Toronto (Ontario) has been exceptionally cold, but reference to the Observatory records shows very clearly that this prevalent idea is unwarranted, as the average temperature of the four months, December to March, was but 0.8 below the normal. Of these four months December was relatively the mildest, with a mean temperature 2.2 above average. February was the coldest with a mean temperature of 18.8 which was 3.7 below average. January was just average, and March 2.2 below average. The abnormal feature of March was the extreme cold of the last week, during which on two days, namely—the 28th and 31st, the temperature was lower than on any corresponding dates back to 1840.

The snowfall of the winter was the heaviest since 1912, but very little greater than that of 1918. It was, however, nearly as heavy as any back to 1877, in which year there was 81 inches. The heaviest fall on record was that of 1870 when 124 inches fell, and 100 inches was also reached or exceeded in 1867, 1871, 1875. It is interesting to note that the average winter snowfall

of the last ten years is precisely the same as the average of the first ten years of observation, 1844 to 1853, which rather outlaws the idea of a diminishing snowfall, and is confirmatory of the theory of climatic pulsations. When one considers the heavy snowfall of the seventies, and some few years of the eighties, it is not surprising that elderly persons often state that snowfall is not what it was in their youth. It is quite possible they may live to see just as heavy winter snowfalls as in years gone by.

There are few instrumental meteorological records of over one hundred years, and it was not until about fifty years ago that meteorological observing stations became numerous. To obtain information as to climatic changes in the past, it has been necessary to seek for facts in the volumes of historians of bygone centuries and to draw inferences from those revealed in archaeological research. Such records do not appear to indicate any steady progressive change of climate in either direction in southern Europe within the past few thousand years, but there appear to be indications of increasing desiccation in parts of Asia. Also certain well known research workers claim that a slight shifting of the climatic zones can best account for the decay of some of the early civilizations of North America.

Be this as it may, it has been amply proven that climatic pulsations of both long and short periods have occurred down through the centuries, and to-day the meteorologist with one slight modification is unable to demonstrate any steady progressive change in the character of our seasons.

The slight modification is that with the deforestation of a country the summers have a tendency towards a somewhat greater heat—and not improbably the winters tend towards greater cold.

Emerson's Poem on "Wealth."

A member sends me the following poem by Ralph Waldo Emerson which many will be pleased to read:

Who shall tell what did befall,
Far away in time, when once,
Over the lifeless ball,
Hung idle stars and suns?
What god the element obeyed?
Wings of what wind the lichen bore,
Wafting the puny seeds of power,
Which, lodged in rock, the rock abrade?
And well the primal pioneer
Knew the strong task to it assigned,
Patient through Heaven's enormous year
To build in matter home for mind.
From air the creeping centuries drew
The matted thicket low and wide,
This must the leaves of ages strew
The granite slab to clothe and hide,
Ere wheat can wave its golden pride.
What smiths, and in what furnace, rolled

(In dizzy æons dim and mute
The reeling brain can ill compute)
Copper and iron, lead and gold?
What oldest star the fame can save
Of races perishing to pave
The planet with a floor of lime?
Who saw what ferns and palms were pressed
Under the tumbling mountain's breast,
In the safe herbal of the coal?
But when the quarried means were piled,
All is waste and worthless, till
Arrives the wise selecting will,
And, out of slime and chaos, Wit
Draws the threads of fair and fit.
Then temples rose, and towns, and marts,
The shop of toil, the hall of arts;
Then flew the sail across the seas
To feed the North from tropic trees;
The storm-wind wove, the torrent span,
Where they were bid the rivers ran;
New slaves fulfilled the poet's dream,
Galvanic wire, strong-shouldered steam.
Then docks were built, and crops were stored,
And ingots added to the hoard.
But, though light-headed man forget,
Remembering Matter pays her debt:
Still, through her motes and masses, draw
Electric thrills and ties of Law,
Which bind the strength of Nature wild
To the conscience of a child.

C. A. C.

MEETINGS OF THE SOCIETY.

AT TORONTO

March 20.—The regular fortnightly meeting was held in the Physics Building at 8 p.m., the President, Mr. W. E. W. Jackson, in the chair.

The librarian's report for January and February showed that 78 periodicals had been received, and mentioned some recent books added to the library.

Prof. Chant stated that the announcement telegraphed about the star Beta Ceti, two weeks ago, was a mistake, and that it had been mistaken for Mira, which was then at its maximum. A memorandum had been sent by Mr. J. A. Pearce from California, who stated that the star was now bright and that its maximum had occurred about 25 days ahead of time. Prof. Chant also exhibited five lantern slides respecting the last eclipse of the sun as photographed by the Lick Observatory party at Wallal, Australia. Two of them were of apparatus used, and three were of the corona taken with the 40-foot camera.

The paper of the evening was read by Mr. Harold Bibby on "A Meteorological Trip in the Mackenzie Basin". Mr. Bibby had been sent on this meteorological expedition to the Mackenzie valley in 1921, and after spending about 18 months there he returned to Toronto last autumn. He spoke of the region in which he travelled as the "hospitable northland". At Fort Good Hope, where he wintered in 1921-2, he had taken 46 sets of observations for azimuth, etc. He had sent up pilot balloon flights each day to determine the velocity and the direction of the wind. Observations were also made for the magnetic dip, and for frequent chronometer comparisons.

On the Mackenzie River, both above and below Fort Good Hope, where he wintered, he saw many new sights, amongst which were the tar sands of the Athabaska, covering an area of 500 square miles. The country has many natural resources which are as yet undeveloped. Much credit is due to the missionaries of the Mackenzie for their devotion to duty. Some of the Sisters of Charity have been in the Northland for as much as twenty years without ever returning south to the more populous parts. "The Ramparts" of the Mackenzie, consisting of limestone, and between 200 and 300 feet high, always present a remarkable appearance. He journeyed as far as Fort Macpherson, and beyond it, showing many interesting lantern slides of scenes photographed on the trip. The aurora is almost a nightly phenomenon in the north, and there were many auroral phenomena to be seen. Of the natives in that territory, the Eskimo are more prosperous than the Indians, of which the Slave tribe were the chief bands he

met with. The railway runs as far north as Fort McMurray, where he joined it and returned to the settled parts of the country.

April 3.—The regular meeting was held at 8 p.m., the President in the chair.

Mr. L. D. Hara, St. Catharines, was elected a member.

Prof. Chant referred to a letter he had received from Mr. H. Westoby, Guelph, respecting a large meteorite seen by him on the night of March 30, at 10.27 p.m. News of the place of its downfall has not yet come to hand. Prof. Chant also mentioned that the staff at Mount Wilson had not been able to confirm the telegram sent out by Flammarion respecting the increase in the brilliance of Beta Ceti, but every item of evidence pointed to the probability that it had been mistaken for Mira, *i.e.*, O Ceti.

Mr. Jackson stated that the prominent aurora on the night of March 24 and also that of the night of March 26, which was rather less prominent than the former one, were concurrent with marked disturbances of the magnetic instruments.

Major Nelles of the Geodetic Survey had written Prof. Chant in regard to a solar halo he had observed in 1902 in which there were three sets of cross-bars of light, with the sun itself in the intersection of the middle cross. A solar halo which Mr. Jackson had recently observed included an ellipse and a complete circle, both visible at the same time.

The paper of the evening was by Mr. Wilson Taylor, M.A., on "Molecular Tension in relation to Cosmic Phenomena". In dividing a gram of water, the process of division can go on, splitting each portion in halves every time, just 79 times, and the last result would be the molecule. A molecule 100,000,000 times magnified would be about the size of an apple. Some forty or fifty years ago scientific men turned aside from the pursuit of general physical problems to the study of electricity exclusively, but this diversion in an exclusive direction has left unexplained some prominent facts in physics, such as surface tension and other unsolved problems. In many particulars, electricity fails to explain the phenomena observed. Mr. Taylor exhibited numerous experiments to show molecular forces actually at work, especially some involving surface tension. These appear when liquids are mingled, but have different specific gravities. One of the prominent features of these experiments is the fact that the spherical form is universal throughout Nature. External cohesion is also one of the phenomena displayed in such circumstances. In the gaseous form there is doubtless conformity to the regular shapes of Nature, but in the liquid state, the molecules may be of any shape. Their surfaces reflect light and scatter it, and this property is one of the objects of enquiry by scientists. Some remarkable properties of molecules are worthy of notice, as for example when their collective strength can resist a pressure of 100 tons per square inch.

Enquiries from members present brought out the particular feature that when liquids are converted into gases, the molecular forces are distributed through the separate molecules, and their aggregate after distribution is just the same as before, *i.e.*, upon the larger mass. This is the case with steam, for example, after conversion from water. The behaviour of molecular forces in vacuo is

still uncertain. Some members expressed doubts as to the same forces being in evidence for large spheres that are visible in molecular forces, and in reply Mr. Taylor pointed out that molecular forces were not the only forces that exist.

April 17.—The regular meeting of the Society was held in the Physics Building at 8 p.m., the President in the chair.

Mr. Hunter pointed out that on the 19th the moon would occult the star Aldebaran; immersion occurs at 5.16 p.m. and emersion at 6.32, and hence the latter event should be observable. He also drew attention to the fact that Mercury at its next eastern elongation of 21° 7′ on May 5th would be in the position most suitable for observation this year.

The paper of the evening was then given by Prof. J. L. Synge, of the Department of Mathematics of the University, on the subject "Space and Time". Prof. Synge's paper will appear in some future issue of the JOURNAL. Prof. Synge began by pointing out that the Greeks loved the study of mathematics apart from any value that might result from its use for material gain. He stated that with modern mathematicians the same thing was true. They began with certain definitions and then derived certain facts. Whether the predicted facts were true physically or not did not lessen the value of the work. However the object always should be to have the basic definitions such that predicted results can be verified physically. This verification is not the work of the mathematician but of the physicist or the astro physicist, as in the case of Einstein's theory. Einstein starting from certain definitions, differing from Newton's, had predicted certain facts and one of these was the amount of bending of light rays passing near the sun. This amount was naturally different from that which Newton predicted and the test applied by the expeditions of last year show that the amount of observed bending agrees more nearly with that predicted by Einstein and hence supports his fundamental definitions. Space was then dealt with. The audience were asked to consider the conditions on the floor of an ideal laboratory far off in space free from any gravitational effects. First a method of measurement of distance was selected, the unit being a rigid metal bar. To decide on what was a straight line four definitions were considered: (1) The straight line on a rigid body where the test of a straight line joining two points is to cut along the tested line and then turn one part about the other. If the line is straight the two edges must remain in contact. (2) The shortest distance between two points is a straight line and is to be obtained by stretching a string between the points. (3) The light ray travels in a straight line. (4) A free particle in motion free from external forces moves in a straight line. When a heavy body was introduced into the floor of the ideal laboratory it resulted in these four definitions producing different straight lines, and in the breaking up of the floor. The 3rd definition gave the problem of light rays passing a heavy body, *i.e.*, the sun, and the lecturer showed how Einstein's predictions had been supported. He then discussed the problem of the change in the perihelion position in a planet's orbit and explained the difference between Einstein's and Newton's theories.

In dealing with Time the method to be used in measuring time is fixed upon as that of the "light-clock" in which a ray of light passing between two parallel mirrors registers a unit of time at each impact on a mirror. Using this clock it was pointed out that clocks could be synchronized easily and perfectly. A definition of simultaneous events was then discussed and some of the remarkable results obtained by using Einstein's units were described. The great difference in the results of measurements of the length of a rapidly moving vessel when measured with a yardstick by a person on the boat, and when measured by timing its passage from the shore by means of time-clocks caused the audience much wonder, but it was pointed out that the cause must be in the units of time and space employed.

Points arising from the paper were discussed by various members of the audience and its clearness of presentation was commented upon very favourably by Prof. Chant and by Prof. DeLury. A hearty vote of thanks moved by Prof. DeLury, seconded by Prof. Beatty, was then tendered to Prof. Synge for his excellent paper.

J. H. HORNING, *Recorder.*

AT WINNIPEG

March 7.—The meeting was held in the usual place, the President occupying the chair.

There was considerable discussion regarding the telescope project. Mr. J. H. McDowell suggested that information and quotations be obtained from other firms than those already written to, particularly from firms in England, and agreed to send in a list of such firms as he would suggest. Mr. Powell spoke strongly for a telescope of longer objective focal length than the one favoured by the telescope committee in its report of Nov. 22, in order to secure higher magnification. The Secretary, who had presented the report of the telescope committee, emphasized the fact that magnification depends also upon the eye-piece, and that the resolving power and the light-gathering power depend upon the diameter of the objective, not upon its focal length. He also stated that the cost of a lens becomes greater as the focal length is decreased, camera lenses offering an example of this. Prof. MacLean felt that selection of an instrument should not be hurried, and spoke for higher magnification. The Secretary stated that there appeared to be two points in the discussion: one, whether selection of an instrument should be delayed to receive further quotations from England; the other, whether convenience and simplicity in use is the prime essential, or whether higher magnifying power would be desirable even at the expense of these. The Secretary stated further, that to secure higher power at the expense of convenience would lead toward a duplication of the University telescope, of which the Society already has the use, through the courtesy of the Department of Astronomy. In securing subscriptions, he had used the slogan: "A telescope that one person can readily carry, simple and convenient in use,

with as high power as is obtainable in such an instrument." This concluded the discussion.

The following persons were elected members:—Mr. S. J. Mackey, of the Customs Department; address, Varsity View Post Office, Man. Miss L. McCullough, of the University of Manitoba, Department of Political Economy; address, 676 Spruce St.

Mr. Allan, occupying the chair, called on Professor MacLean for the lecture, entitled: "Some Famous Problems in Mathematics." With the skilful treatment by the lecturer, the subject became most interesting and easy to follow. Actual mathematical analysis was largely omitted, the lecturer explaining the nature of the problems and the circumstances attendant to their origin and to their solution. He spoke of some of the mathematicians who had been concerned, and of mathematical prodigies, or lightning calculators. Among other subjects discussed in the lecture were: the "perfect numbers" of Euclid and a formula for computing them; prime numbers and the proof that there is an unlimited number of primes; historical incidents in the solution and attempt at solution of equations of higher degree; the problem of Dido, connected with the founding of the ancient city of Carthage.

Mr. Allan expressed his appreciation of the lecture, and regret that it was not more largely attended, the title having been more awesome than the subject as treated by the lecturer. Fr. Morton asked about the education of prodigies, and Professor MacLean corroborated his idea, that they lose rather than profit by attempts at their education. Mr. Miller expressed strong appreciation of the lecture, and said that he had never heard a mathematician tell about his subject so well, although he had profited much in the past by the rare occasions when a mathematician would tell about something, without actually going into the analysis of it.

H. B. Allan, *Secretary.*

AT LONDON

March 9.—The meeting was held in the Science Building of the University. Professor W. J. Patterson spoke on "what the Spectroscope tells us about the stars". Prof. Patterson traced the development of spectroscopy from Newton down to the present time. By means of coloured charts he showed the three kinds of spectra, *viz.*, continuous spectra, bright line spectra, and absorption spectra. The manner in which these spectra are obtained was explained as it is embodied in the following laws:—

1. When the source of light is an incandescent solid or liquid or gas under high pressure, the spectrum consists of a continuous band of colours.

2. When the source of light is an incandescent gas under low pressure, the spectrum consists of a number of bright lines which have definite positions for each element in the source.

3. When the light that would produce a continuous spectrum passes through a relatively cooler gas, dark lines appear in the spectrum at exactly the positions at which bright lines would appear if this gas were the source of light.

4. When the source of light and the receiver are receding from each other, the lines of the spectrum are shifted towards the red end of the spectrum; when the source and the receiver are approaching each other, the lines are shifted towards the blue. The amount of this shift may be measured and from it the relative speed of reversion or approach may be determined.

The lecturer explained how by means of the fourth law we can determine the period of the rotation of the sun by obtaining spectra from both limbs of the sun.

Dr. Kingston then explained how the comparison spectra are actually obtained by the telescope, and by means of lantern slides showed how the revolution of spectroscopic double stars is determined.

A demonstration was then given with a spectroscope and the following spectra were observed:—

1. The continuous spectrum from the incandescent filament of an electric light bulb.

2. The two bright sodium lines from a sodium flame.

3. The bright line spectrum from the aluminium spark, that is, the bright line spectrum of aluminium vapour *not* under high pressure.

Opportunity was given each member present to observe these spectra directly.

The use of the spectroscope was obtained through the courtesy of Dr. R. C. Dearle of the Physics Department, whose courtesy was appreciated by the Society.

AT VICTORIA

February 27.—A regular meeting of the Society was held in the Auditorium of the Girls' Central School at 8 p.m., the President, Mr. W. E. Harper, in the chair.

Mr. Geo. H. Dean, 1018 Park Boulevard, was duly elected.

The newly installed "Question Box" functioned as follows:—

(1) Explain the terms "Right Ascension" and "Declination" of a Star. Answered by Mr. Drewry.

(2) Are the signs of the Zodiac of any use in Modern Science? Answered by Dr. Young.

(3) As meteors become oxydized when they reach the earth's atmosphere, will this not in time decrease the number? Answered by Mr. W. H. Christie.

(4) What is meant by "Venus transits"? Answered by Mr. Harper.

The President then introduced the lecturer of the evening, Dr. L. K. Poyntz, who spoke on " 'X' Rays, their nature and some of their uses".

The development of our ideas of atomic structure was briefly sketched. Chemists first used the word "Atom", which was somewhat unfortunate, and until recently the ultimate particle of an element was considered indivisible.

The modern view was next explained. The hydrogen atom was taken first as an illustration, the nucleus with its positive charge and the electron with its negative charge.

Electricity, stated Dr. Poyntz, in every form is a multiple of this unit. Probably there is no such thing as positive electricity, it is merely the absence of negative.

Helium was next illustrated and finally uranium. It has 92 outside electrons and 144 inside ones, the physical properties being determined by the inside electrons, the chemical by the outside ones.

Wave-motion was next explained. The senses are only able to detect a limited number of ether-waves. From a few millimetres to miles we have Hertzian waves, with shorter wave lengths we have heat waves, still shorter a dull red glare and we then pass this visible spectrum to ultra violet. After a big gap we have "X" rays and finally the Gamma rays from radium.

The waves of all these rays have a uniform speed of 186,000 miles per second, and only differ in their length.

The lecturer gave an account of the discovery of "X" rays, their biological effects, a description of present-day apparatus, the high voltage (300,000) sometimes used—and finally the uses to which "X" rays are put.

On motion of Dr. Plaskett, seconded by Mr. W. H. Christie, a hearty vote of thanks was accorded to the lecturer.

F. Moore, *Secretary.*

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